Nanosurfer Flash Mobs: E-Field-Choreographed Silver Migration on Graphene Oxide

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Graphene oxide (GO) is a 2D insulative material whose conductivity can be partially restored in localized regions via photothermal reduction with a focused laser beam (FLB). While silver migration is well-known in thick-film ICs, it has yet to be studied on thin-film materials like GO. This paper aims to characterize and understand the mechanism behind silver migration on GO and further investigate its novel applications in controlling nanoparticle assembly on GO. Silver migration on GO was characterized through electrical testing coupled with Fluorescence Microscopy (FM) under Bright Field and Yellow excitation (530-580 nm), and it was found that the strength and shape of applied E-field directed the growth of Ag dendrites. The dendrites were confirmed to be silver using Scanning Electron Microscopy and Energy Dispersive X-ray Spectroscopy. Atomic Force Microscopy was used to correlate the thickness of the GO layers to their respective optical colors. From our characterization study, a mechanism for silver migration unique to GO involving an irremovable interlayer water between GO sheets serving as the electrolyte was proposed. It was then confirmed with a controlled environment study revealing ice crystals at low temperatures. The permanence of this interlayer water allows for the disappearance of dendrites through oxidation and dissolution into the water. After establishing the understanding of dendritic growth patterns, the shape of dendrite formation was controlled into certain desired patterns by altering the electric field with FLB-treated GO. This paves the way for an alternative low-cost silver nanoparticle assembly method requiring only a low-powered laser and low voltage.